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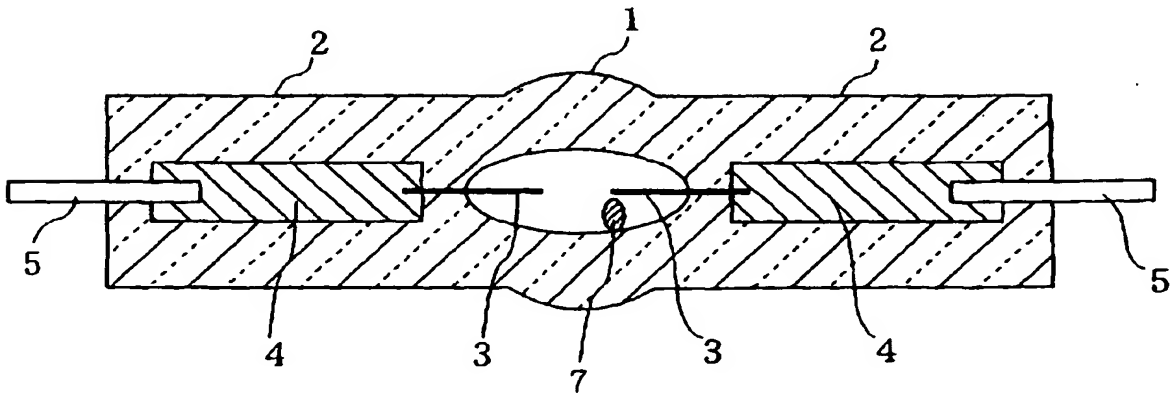
(54) Mercury-free metal halide-lamp

(57) A lamp voltage corresponding to a lamp comprising mercury is obtained by comprising at least a rare gas, a trivalent of indium halide and a thallium iodide in an arc tube 1, and thereby a long life can be accomplished. In addition, when an enclosed amount of the trivalent of indium halide is approximately 90.0mg/cc or less per unit internal volume of the arc tube and the rare gas is xenon gas with an enclosed pressure of 2.5MPa or less, the luminous flux and the light colour most appropriate for a light source for motor vehicle headlights are obtained. Furthermore, when the thallium iodide is enclosed, the lamp voltage can be made even higher and the luminous flux can be increased.

Fig. 1



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Description

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0001] The present invention relates to a mercury-free metal-halide lamp which is usable for general luminaries, and motor vehicle headlights combined with reflectors and the like.

(2) Description of the Prior Arts

[0002] In a conventional metal-halide lamp, rare gas, metal halide (solid matter) and, additionally, mercury are enclosed in an arc tube. Rare gas of these enclosures is enclosed principally in order to facilitate a starting of a lamp and to obtain a high light output immediately after the starting, metal halide is enclosed in order to obtain an appropriate light output during a stable operation, and mercury is enclosed in order to obtain a sufficiently high voltage between the electrodes damp voltage), which is required for the stable operation of the lamp.

[0003] A high voltage between the electrodes can be obtained in the lamp in operation particularly by the enclosure of mercury, and thereby the lamp is operated at a low lamp current. As a result, the heat load of the electrodes (Joule loss) is reduced and the lamp can be operated for a long time up to several thousand hours.

[0004] A lamp appropriate for motor vehicle headlights, for instance, disclosed in Japanese Unexamined Patent Publication No. 59-111244, is known as a concrete example of conventional metal-halide lamps. The conventional metal-halide lamp according to the Publication will be described below showing in Fig. 12.

[0005] In Fig. 12, 101 indicates an arc tube made of quartz, and 102 at both ends of the arc tube 101 indicates a seal portion. 103 indicates a pair of electrodes made of tungsten, 104 indicates a molybdenum foil, and 105 indicates a lead wire made of molybdenum. The electrodes 103 are connected electrically with an end of the molybdenum foil 104 sealed in the seal portion 102, and additionally, the lead wire 105 is connected electrically with the other end of the molybdenum foil 104.

[0006] The tips of the electrodes 103 in the arc tube 101 are disposed so that a distance between the tips, namely, a distance between the electrodes is approximately 4.2 (mm). An internal volume of the arc tube 101 is approximately 0.03 (cc). Approximately 0.7 mg (approximately 1.1 mg/cc per unit internal volume of the arc tube) of mercury 106; approximately 0.3 mg in total (approximately 12.0 mg/cc per unit internal volume of the arc tube) of halide 107 composed of sodium iodide, scandium iodide and thorium iodide; and xenon gas with a pressure of 0.7MPa at room temperature, not shown in Fig. 16, are enclosed inside the arc tube 101.

[0007] In the above-mentioned metal-halide lamp, the lamp voltage becomes approximately 70 to 80 V. Consequently, for instance, in the case of operating at a lamp power of approximately 35W, the lamp current becomes approximately 0.4 to 0.5 A.

[0008] Thus, a high lamp voltage is obtained by mercury. As a result, the above-mentioned conventional metal-halide lamp can be operated at a low current, and thereby this conventional metal-halide lamp has a long life up to approximately two thousand hours.

[0009] As described above, the enclosure of mercury brings the increase of the lamp voltage, and thereby a long lamp life up to several thousand hours is provided for us.

[0010] However, on the other hand, the above-mentioned conventional metal-halide lamp has a disadvantage of causing high manufacturing costs frequently because of requiring the step of injecting liquid mercury for manufacturing. Moreover, in recent years, metal-halide lamps comprising no mercury have been desired in consideration of the global environment.

[0011] However, if mercury is removed from the above-mentioned conventional metal-halide lamp, the lamp voltage drops to approximately 25 V. In this case, the lamp current in operation becomes approximately 1.5 A, which is approximately three times as high as a conventional metal-halide lamp wherein mercury is enclosed. Consequently the heat load of the electrodes (Joule loss) is increased and the evaporation of the electrode becomes active. Therefore, in a mercury-free lamp having a constitution in which mercury is merely removed from a conventional metal-halide lamp, the problem is that the arc tube is blackened in no more than several tens of hours and reaches the end of its life in a very short time. Such a problem becomes conspicuous, particularly in a so-called short-arc lamp with an arc length (a distance between the electrodes) of approximately 10 mm or less.

[0012] In view of the above-mentioned points, the purpose of the present invention is to provide a mercury-free metal-halide lamp wherein a lamp life can be made longer by raising the lamp voltage, and simultaneously a luminous flux emitted from the lamp can be increased (or a decrease in a luminous flux can be lessened).

SUMMARY OF THE INVENTION

[0013] In order to accomplish the above-mentioned purpose, the present invention is characterized by a mercury-free metal halide lamp comprising in its arc tube at least a rare gas and a trivalent of indium halide InX_3 (X: halogen).

[0014] Thus, it is possible to obtain a high lamp voltage corresponding to a metal halide lamp comprising mercury. That is, the lamp voltage can be made higher greatly as compared with the case of comprising no InX_3 and the case of comprising a monovalent of indium halide InX. Therefore, since an electric current applied to the lamp can be decreased, the heat load of the electrodes is reduced and the blackening of an arc tube by the sputtering of the electrodes is restrained. As a result, a long lamp life can be obtained.

[0015] The above-mentioned rare gas can comprise at least Xe (xenon), and an enclosed pressure of the above-mentioned Xe can be determined in a range of 0.1 MPa, preferably 0.7MPa, to 2.5MPa at room temperature. Furthermore, it is possible to raise the lamp voltage as well as increase the whole luminous flux by comprising a thallium halide. In particular since the ratio of a rising rate of the lamp voltage to a rising rate of the enclosed pressure of Xe is higher than the case of comprising a monovalent of indium halide InX, it is easily possible to raise the lamp voltage further by raising the enclosed pressure.

[0016] The present invention is characterized by comprising a scandium halide or a sodium halide.

[0017] The present invention is characterized by determining the enclosed amount of the above-mentioned rare gas, the enclosed amount of the above-mentioned trivalent of indium halide and the operating power of the above-mentioned lamp so that the lamp voltage per unit distance between the electrodes is 100 V/cm or more and the luminous efficiency is 60l m/W.

[0018] The present invention is characterized in that the enclosed amount of the above-mentioned trivalent of indium halide is 90.0 mg/cc or less per unit internal volume of the arc tube.

[0019] The present invention is characterized in that the operating power of the above-mentioned lamp is determined in a range of 25W to 55W.

[0020] The present invention is characterized in that the above-mentioned trivalent of indium halide is at least one of iodide and bromide.

[0021] Thus, a lamp life is made longer by raising the lamp voltage certainly, and simultaneously a light with a large luminous flux can be emitted. It is possible to obtain such a lamp as appropriate for motor vehicle headlights.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Fig. 1 is a cross sectional view showing a mercury-free metal-halide lamp in Embodiments 1 and 2.

[0023] Fig. 2 is a graph showing a relation between the enclosed amount of a trivalent of indium iodide (InI_3) and the lamp voltage in a mercury-free metal-halide lamp of Embodiment 1.

[0024] Fig. 3 is a graph showing a relation between the enclosed pressure of xenon gas and the lamp voltage in a mercury-free metal-halide lamp of Embodiment 1.

[0025] Fig. 4 is a graph showing a relation between the enclosed pressure of xenon gas and the whole luminous flux in a mercury-free metal-halide lamp of Embodiment 1.

[0026] Fig. 5 is a graph showing a relation between the enclosed amount of a trivalent of indium iodide (InI_3) and the whole luminous flux in a mercury-See metal-halide lamp of Embodiment 1, which is operated at a lamp power of 45W.

[0027] Fig. 6 is a graph showing a relation between the enclosed amount of a trivalent of indium iodide (InI_3) and the whole luminous flux in a mercury-free metal-halide lamp of Embodiment 1, which is operated at a lamp power of 35W.

[0028] Fig. 7 is a graph showing a relation between the enclosed amount of thallium iodide and the lamp voltage in a mercury-free metal-halide lamp of Embodiment 2.

[0029] Fig. 8 is a graph showing a relation between the enclosed amount of thallium iodide and the whole luminous flux in a mercury-free metal-halide lamp of Embodiment 2.

[0030] Fig. 9 is a graph showing a relation between the enclosed pressure of xenon gas and the lamp voltage in a mercury-free metal-halide lamp of Embodiment 2.

[0031] Fig. 10 is a graph showing a relation between the enclosed pressure of xenon gas and the whole luminous flux in a mercury-free metal-halide lamp of Embodiment 2.

[0032] Fig. 11 is a graph showing the lamp voltage per unit distance between the electrodes and the luminous efficiency in a mercury-free metal-halide lamp of Embodiments 1, 2 and a conventional metal-halide lamp.

[0033] Fig. 12 is a cross sectional view showing a conventional metal-halide lamp.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(Embodiment 1)

[0034] Embodiment 1 of the present invention will be described below. Fig. 1 is a cross sectional view showing a mercury-free metal-halide lamp in Embodiment 1 of the present invention.

[0035] In Fig. 1, 1 indicates an arc tube made of quartz, and 2 at both ends of the arc tube 1 indicates a seal portion. 3 indicates a pair of electrodes made of tungsten, 4 indicates a molybdenum foil, and 5 indicates a lead wire made of molybdenum. The electrodes 3 are connected electrically with an end of the molybdenum foil 4 sealed in the seal portion 2, and additionally, the lead wire 5 is connected electrically with the other end of the molybdenum foil 4.

[0036] The tips of the electrodes 3 in the arc tube 1 are disposed so that a distance between the tips, namely, a distance between the electrodes is approximately 4.2 (mm).

[0037] An internal volume of the arc tube 1 is approximately 0.025 (cc). Halide 7 composed of approximately 0.2 mg of a trivalent of indium iodide (InI_3) (approximately 8.0 mg / cc per unit internal volume of the arc tube), approximately 0.19 mg of scandium iodide (approximately 8.0 mg/cc per unit internal volume of the arc tube), and approximately 0.16 mg of sodium iodide (approximately 6.4mg/cc per unit internal volume of the arc tube); and xenon gas with a pressure of approximately 0.7MPa at room temperature, not shown in Fig. 1, are enclosed inside the arc tube 1.

[0038] The noticeable characteristic of the constitution of a metal-halide lamp in Embodiment 1, as compared with the constitution of a conventional metal-halide lamp, is that the constitution comprises no mercury, and the enclosed indium iodide is a trivalent of indium iodide (InI_3). This mercury-free metal-halide lamp is driven by a voltage with a rectangular wave of, for instance, 150 to 250 Hz.

[0039] The notable fact of a mercury-free metal-halide lamp in Embodiment 1, wherein a trivalent of indium iodide (InI_3) is enclosed, is that the lamp is operated at a very high lamp voltage despite no mercury: For instance, the lamp voltage of the lamp in Embodiment 1 is approximately 55 V in the case of operating at a lamp power of 45 W, and the lamp voltage is approximately 50 V in the case of operating at a lamp power of 35W. When a lamp wherein a trivalent of indium iodide (InI_3) is removed from the lamp in Embodiment 1 is operated at a lamp power of 25 to 50W, the lamp voltage is no more than approximately 27 V. In addition, when a lamp, wherein a monovalent of indium iodide (InI) is substituted for a trivalent of indium iodide (InI_3) in a mercury-free metal-halide lamp of Embodiment 1, is operated at a lamp power of 35W, the lamp voltage is approximately 45 V, which does not reach the lamp voltage of the lamp in Embodiment 1.

[0040] Thus, since a high lamp voltage is obtained by enclosing InI_3, the lamp in Embodiment 1 can be operated for several hundred hours or more without the blackening of the arc tube, namely, any substantial change.

[0041] A mercury-free metal-halide lamp, wherein approximately 0.2 mg of a trivalent of indium iodide (InI_3) (approximately 8.0 mg/cc per unit internal volume of the arc tube) is enclosed, is described in the above-mentioned example. As shown in Fig. 2, it is found that when the enclosed amount of a trivalent of indium iodide (InI_3) is increased, an even higher lamp voltage is obtained, therefore the lamp voltage affects the life advantageously. Fig. 2 is a graph showing a relation between the lamp voltage and the enclosed amount of a trivalent of indium iodide (InI_3) in the case of operating at a lamp power of 35W or 45W while increasing the enclosed amount of a trivalent of indium iodide (I_nI_3) in a mercury-free metal-halide lamp of Embodiment 1. More enclosed amount of a trivalent of indium iodide (InI_3) brings higher lamp voltage.

[0042] An effect of a rise in the lamp voltage by an increase in the enclosed amount of a trivalent of indium iodide (InI_3) is obtained regardless of such other factors as the lamp power, a distance between the electrodes, an internal volume of the arc tube 1, the enclosed pressure of the Xe gas, the amount of scandium iodide and sodium iodide, and the kind and the amount of other halides enclosed with the a trivalent of indium iodide (InI_3).

[0043] As shown in Fig. 3, an even higher lamp voltage is obtained when the enclosed pressure of xenon gas is raised. In addition, the ratio (gradient) of a rising rate of the lamp voltage to a rising rate of the enclosed pressure becomes higher than the case of comprising a monovalent of indium iodide InI. That is, the lamp voltage can be raised further by raising the enclosed pressure.

[0044] Moreover, as shown in Fig. 4, when the enclosed pressure of xenon gas is raised, the whole luminous flux increases approximately linearly. Fig. 4 is a graph showing a relation, under a parameter of the enclosed amount of a trivalent of indium iodide (InI_3), between the enclosed pressure (an equivalent at room temperature) of xenon gas and the whole luminous flux in a mercury-free metal-halide lamp of Embodiment 1, which is operated at a lamp power of 45W. The notable fact of a mercury-free metal-halide lamp in Embodiment 1, wherein a trivalent of indium iodide (InI_3) is enclosed, is that a rise in temperature at the hotspot (an area with the highest temperature: the top outside of the arc tube 1 in the case of operating the arc tube 1 while maintaining horizontally) of the arc tube 1 by an increase in the enclosed pressure of xenon gas is negligibly small, therefore there is little possibility of an expansion of the arc tube 1 by an increase in the enclosed pressure of xenon gas.

[0045] As described above, a mercury-free metal-halide lamp in Embodiment 1, wherein at least xenon gas and a

trivalent of indium iodide (InI_3) are enclosed in the arc tube 1. has such a characteristic that when the enclosed pressure of xenon gas is increased, the whole luminous flux increases with little rise in temperature at the hotspot; and when the enclosed amount of a trivalent of indium iodide (InI_3) is increased, the lamp voltage increases. These effects are obtained regardless of such other factors as the lamp power, a distance between the electrodes, an internal volume of the arc tube 1, the amount of scandium iodide and sodium iodide, and the kind and the amount of other halides enclosed with the trivalent of indium iodide (InI_3).

[0046] The enclosed pressure of xenon gas is described below. In order to obtain a lamp for practical use, it is preferable to determine an upper limit of the enclosed pressure of xenon gas at approximately 2.5 M Pa (an equivalent at room temperature) in a mercury-free metal-halide lamp of Embodiment 1. The reason is that if xenon gas with a pressure above approximately 2.5MPa is enclosed in a mercury-free metal-halide lamp of Embodiment 1, it is not preferable that there is a higher possibility that the enclosures inside the arc tube 1 leak in operation near a connection portion between the electrodes 3 and the molybdenum foil 4. More preferably, the upper limit of the enclosed pressure of xenon gas is approximately 2.0MPa. Meanwhile, its appropriate lower limit is approximately 5 to 20kPa, which facilitates a starting of the lamp. However, more preferably, the lower limit is approximately 0.1MPa when a mercury-free metal-halide lamp in the present invention is used as a light source for motor vehicle headlights wherein a starting of light is required in a short time. It is more preferable to determine the lower limit at a value above 0.7MPa or 1MPa in order to lessen a decrease in a luminous flux due to the enclosure of InI_3 or supplement the luminous flux.

[0047] Next, the enclosed amount of a trivalent of indium iodide (InI_3) and the luminous flux are described. In a mercury-free metal-halide lamp in the present invention, more enclosed amount of a trivalent of indium iodide (InI_3) brings higher lamp voltage, and thereby the lamp voltage is to the advantage of the life. When a mercury-free lamp in Embodiment 1 is used as a light source for motor vehicle headlights, it is preferable to determine the enclosed amount of a trivalent of indium iodide (InI_3) at a value below approximately 90.0 mg/cc per unit internal volume of the arc tube. The reason is as follows:

[0048] That is, the whole luminous flux of approximately 1100 (1 m) is obtained at a consumption power of 55W in a halogen lamp used frequently for motor vehicle headlights nowadays. Meanwhile, in a lamp in the present invention, as shown in Fig. 5, when the enclosed amount of a trivalent of indium iodide (InI_3) is determined at a value below approximately 90.0 mg/cc per unit internal volume of the arc tube, more luminous flux than a conventional halogen lamp is obtained at a consumption power of merely 45W, whereby a more economical lamp is obtained. Fig. 5 is a graph showing a relation, under a parameter of the enclosed pressure (an equivalent at room temperature) of xenon gas, between the whole luminous flux and the enclosed amount of a trivalent of indium iodide (InI_3) in a mercury-free metal-halide lamp of Embodiment 1, which is operated at a lamp power of 45W. As shown in Fig. 5, when the enclosed pressure of xenon gas is 2.5 MPa (an equivalent at room temperature), the maximum of allowable values in a mercury-free lamp of Embodiment 1, the luminous flux of approximately 1100 (1 m) or more is obtained on the condition that the enclosed amount of a trivalent of indium iodide (InI_3) is approximately 90.0 mg/cc or less per unit internal volume of the arc tube. When the enclosed pressure of xenon gas is lower than 2.5MPa, for instance, 2.0MPa (an equivalent at room temperature), the preferable maximum of allowable values in a mercury-free lamp of Embodiment 1, an appropriate upper limit of the enclosed amount of a trivalent of indium iodide (InI_3) for obtaining the luminous flux of approximately 1100 (1 m) or more is approximately 70.0 mg/cc per unit internal volume of the arc tube in a mercury-free metal-halide lamp in the present invention. That is, when the enclosed pressure of xenon gas is 2.0MPa, the luminous flux of approximately 1100 (1 m) or more is obtained on the condition that the enclosed amount is approximately 70.0 mg/cc or less per unit internal volume of the arc tube, whereby a more economical lamp than a conventional halogen lamp is obtained.

[0049] Similarly, Fig. 6 is a graph showing a relation, under a parameter of the enclosed pressure (an equivalent at room temperature) of xenon gas, between the whole luminous flux and the enclosed amount of a trivalent of indium iodide (InI_3) in a mercury-free metal-halide lamp of Embodiment 1, which is operated at a lamp power of 35W. When the enclosed amount of a trivalent of indium iodide (InI_3) is determined at a value below approximately 50.0 mg/cc per unit internal volume of the arc tube, more luminous flux than a conventional halogen lamp is obtained at a consumption power of merely 35W, whereby a more economical lamp is obtained. When the enclosed pressure of xenon gas is 2.5MPa (an equivalent at room temperature), the luminous flux of approximately 1100 (1 m) or more is obtained on the condition that the enclosed amount of a trivalent of indium iodide (InI_3) is approximately 50.0 mg/cc or less per unit internal volume of the arc tube. When the enclosed pressure of xenon gas is lower, for instance, 2.0MPa (an equivalent at room temperature), an appropriate upper limit of the enclosed amount of a trivalent of indium iodide (InI_3) is approximately 40.0 mg/cc per unit internal volume of the arc tube. That is, the luminous flux of approximately 1100 (1 m) or more is obtained on the condition that the enclosed amount is approximately 40.0 mg/cc or less per unit internal volume of the arc tube, whereby a more economical lamp than a conventional halogen lamp is obtained.

[0050] As described above, in a constitution of a mercury-free metal-halide lamp in the present invention, when xenon gas with an appropriate pressure below an upper limit of 2.5MPa is enclosed and a trivalent of indium iodide (InI_3) with an appropriate amount below an upper limit of approximately 90.0 mg/cc per unit internal volume of the arc

tube is enclosed, it is possible to obtain a mercury-free metal-halide lamp most appropriate as a light source for motor vehicle headlights, wherein, in the case of operating at a lamp power above approximately 25W, there is no possibility of breaking the airtightness in the arc tube 1; a high lamp voltage is obtained, and thereby the lamp has a long life; and more luminous flux than a halogen lamp occurs.

[0051] As regards a lamp power, when a mercury-free lamp in Embodiment 1 is operated at a higher lamp power, more luminous flux is obtained. However, an upper limit of a consumption power of a mercury-free lamp in Embodiment 1 is actually approximately 55W if the lamp is used for motor vehicle headlights. The reason is that an operation in a range above a consumption power of a conventional halogen lamp is uneconomical and not preferable.

[0052] Next, the light color of a mercury-free metal-halide lamp in Embodiment 1 is described. In a mercury-free metal-halide lamp in Embodiment 1, when xenon gas with an appropriate pressure below an upper limit of 2.5MPa is enclosed and a trivalent of indium iodide (InI_3) with an appropriate amount below an upper limit of approximately 90.0 mg/cc per unit internal volume of the arc tube is enclosed, it is confirmed that the light color of a mercury-free lamp in Embodiment 1, in the case of operating at a lamp power of approximately 25 to 55 W, is in a chromaticity range of the white light source specified in HID light sources for motor vehicle headlights (JEL 215) by the Japan Electrical Lamp Manufacturers Association. That is, by means of determining the kind and the amount of the enclosures comprising a trivalent of indium iodide (InI_3) and a rated power as described above, a chromaticity coordinate of an emitted light of the lamp can be in a chromaticity range of the following equations in a CIE1931 x,y chromaticity diagram :

$x \geqq 0.310$,
$x \leqq 0.500$,
$y \leqq 0.150 + 0.640x$,
$y \leqq 0.440$,
$y \geqq 0.050 + 0.750x$, and
$y \geqq 0.382$ (in the case where $x \geqq 0.44$).

[0053] Accordingly a mercury-free metal-halide lamp in Embodiment 1 is completely usable as a light source for motor vehicle headlights within the above-mentioned limited range of the enclosed pressure of xenon gas, the enclosed amount of a trivalent of indium iodide (InI_3), and a lamp power.

(Embodiment 2)

[0054] Embodiment 2 of the present invention will be described below. The structural constitution of this lamp is the same as the above-mentioned lamp of Embodiment 1 shown in Fig. 1, and this lamp differs from the above-mentioned lamp of Embodiment 1 in the kind of enclosed halide 7, and approximately 1.4M Pa (an equivalent at room temperature) of the enclosed pressure of xenon gas. That is, the halide 7 is composed of approximately 0.1 mg of a trivalent of indium iodide (InI_3) (approximately 4.0 mg/cc per unit internal volume of the arc tube), approximately 0.1 mg of thallium iodide TlI (approximately 4.0 mg/cc per unit internal volume of the arc tube), approximately 0.19 mg of scandium iodide (approximately 8.0 mg/cc per unit internal volume of the arc tube), and approximately 0.16 mg of sodium iodide (approximately 6.4 mg/cc per unit internal volume of the arc tube).

[0055] The noticeable characteristic of the constitution of a metal-halide lamp in Embodiment 2, as compared with the constitution of a conventional metal-halide lamp, is that, like Embodiment 1, the constitution comprises no mercury and the enclosed indium iodide is a trivalent of indium iodide (InI_3), and additionally thallium iodide is enclosed.

[0056] The notable fact of a mercury-free metal-halide lamp in Embodiment 2 is that the lamp is operated at a very high lamp voltage despite no mercury. Fig. 7 shows the changes of the lamp voltage in the case of operating at a lamp power of 35W like Embodiment 1 while changing the enclosed amount of thallium iodide (TlI). When thallium iodide (TlI) is added, the lamp voltage rises dramatically, and the more amount is added, the more the lamp voltage rises. For instance, the lamp voltage in the case of operating at a lamp power of 35 W is approximately 70 V. Thus, since a high lamp voltage is obtained, the lamp in Embodiment 2 can be operated for several hundred hours or more without the blackening of the arc tube, namely, any substantial change.

[0057] The notable fact of the lamp in Embodiment 2 is that greatly much luminous flux of 3250 (1 m) can be obtained in the case of operating at a lamp power of 35W.

[0058] Fig. 8 shows the changes of the luminous flux in the case of operating at a lamp power of 35W like Embodiment 1 while changing the enclosed amount of thallium iodide (TlI) enclosed in the lamp. As shown in Fig. 8, large luminous flux can be obtained by adding thallium iodide (TlI), and the more amount of thallium iodide is enclosed, the more the luminous flux increases.

[0059] An effect of a rise in the lamp voltage and an increase in the luminous flux by an increase in the enclosed amount of the above-mentioned thallium iodide (TlI) is obtained regardless of such other factors as the lamp power, a distance between the electrodes, an internal volume of the arc tube 1, the enclosed pressure of the Xe gas, the amount

of scandium iodide and sodium iodide, and the kind and the amount of other halides enclosed with the thallium iodide.

[0060] Moreover, when the enclosed pressure of xenon (Xe) gas is increased, it is found that the lamp voltage and the luminous flux increase further. Figs. 9 and 10 show a relation between the enclosed pressure of Xe and the lamp voltage or the luminous flux in the case of operating at a lamp power of 35W. As shown in Figs. 9 and 10, it is found that the more the enclosed pressure of Xe rises, the more the lamp voltage and the luminous flux rise. However, as described in Embodiment 1, it is desirable to determine the enclosed pressure of xenon gas at a value below 2.5MPa, more preferably, 2.0MPa, as well as above approximately 5 to 20kPa, more preferably, approximately 0.1MPa, far preferably, 0.7MPa or 1M Pa, in terms of the maintenance of airtightness and an easy starting.

[0061] As described above, a mercury-free metal-halide lamp in Embodiment 2, wherein at least xenon gas, a trivalent of indium iodide (InI_3) and thallium iodide are enclosed in the arc tube 1, has such a characteristic that when the enclosed amount of thallium iodide is increased, the lamp voltage and the whole luminous flux increase as well as when the enclosed pressure of xenon gas is increased, the lamp voltage and the whole luminous flux increase. This effect is obtained regardless of such other factors as the lamp power, a distance between the electrodes, an internal volume of the arc tube 1, the amount of scandium iodide and sodium iodide, and the kind and the amount of other halides enclosed with the thallium iodide.

[0062] Accordingly, in a constitution of a mercury-free metal-halide lamp in Embodiment 2, when xenon gas with an appropriate pressure below an upper limit of 2.5MPa is enclosed and indium iodide, which is a trivalent of indium iodide, and thallium iodide are enclosed, it is possible to obtain a mercury-free metal-halide lamp most appropriate as a light source for motor vehicle headlights, wherein a high lamp voltage is obtained, and thereby the lamp has a long life; and more luminous flux than a halogen lamp occurs.

[0063] As regards a lamp power, like Embodiment 1, when a mercury-free lamp in Embodiment 2 is operated at a higher lamp power, more luminous flux is obtained. However, an upper limit of a consumption power of a mercury-free lamp in Embodiment 2 is actually approximately 55W if the lamp is used for motor vehicle headlights. The reason is that an operation in a range above a consumption power of a conventional halogen lamp is uneconomical and not preferable.

[0064] Like Embodiment 1, in a mercury-free metal-halide lamp in Embodiment 2, when xenon gas with an appropriate pressure below an upper limit of 2.5MPa is enclosed and a trivalent of indium iodide (InI_3) and thallium iodide with an appropriate amount below an upper limit of approximately 90.0 mg/cc per unit internal volume of the arc tube are enclosed, it is confirmed that the light color of a mercury-free lamp in Embodiment 2, in the case of operating at a lamp power of approximately 25 to 55W, is in a chromaticity range of the white light source specified in HID light sources for motor vehicle headlights (JEL 215) by the Japan Electrical Lamp Manufacturers Association. That is, by means of determining the kind and the amount of the enclosures comprising a trivalent of indium iodide (InI_3) and thallium iodide and a rated power as described above, a chromaticity coordinate of an emitted light of the lamp can be in a chromaticity range of the following equations in a CIE1931 x,y chromaticity diagram:

$x \geqq 0.310$,
$x \leqq 0.500$,
$y \leqq 0.150 + 0.640x$,
$y \leqq 0.440$,
$y \geqq 0.050 + 0.750x$, and
$y \geqq 0.382$ (in the case where $x \geqq 0.44$).

Accordingly, a mercury-free metal-halide lamp in Embodiment 2 is completely usable as a light source for motor vehicle headlights within the above-mentioned limited range of the enclosed pressure of xenon gas, the enclosed amount of a trivalent of indium iodide (InI_3), and a lamp power.

[0065] The following table 1 shows a comparison in the lamp voltage and the luminous flux between a lamp (comprising InI_3, or InI_3 and TlI) of the above-mentioned Embodiments 1 and 2, a lamp comprising InI and a lamp comprising neither InI_3 nor InI. Fig. 11 shows the lamp voltage per unit distance between the electrodes and the luminous efficiency (the whole luminous flux per unit lamp power) in these lamps and a conventional lamp. As shown in Fig. 11, a lamp with the lamp voltage per unit distance between the electrodes of 100 V/cm or more and the luminous efficiency of 60 l m/W or more (an area with oblique lines in Fig. 11) can be obtained by comprising a trivalent of indium iodide (InI_3). As regards an effect of a rise in voltage by the enclosure of InI_3 a rise (an arrow P in a solid line) in the lamp voltage of a lamp (lamp B) comprising InI_3 with a standard of a lamp (lamp A in Fig. 11) comprising neither InI_3 nor InI becomes larger than a rise (an arrow Q in a broken line) in the lamp voltage of a lamp (lamp C) comprising InI. Arise in the lamp voltage in the case (an arrow R in a solid line, lamp D) of raising the enclosed pressure of Xe (1.4 MPa) in the above-mentioned lamp B comprising InI_3 becomes much larger than the case (an arrow S in a broken line, lamp E) of raising the enclosed pressure of Xe in the above-mentioned lamp A comprising neither InI_3 nor InI. In particular by means of determining the enclosed amount of InI_3 like the above-mentioned lamp D, the lamp voltage per unit distance between

the electrodes can easily be made 140 V/ cm or more with approximately the same value of the whole luminous flux (the luminous efficiency) as the lamp A comprising no InI_3, and consequently a general cheap driver circuit can be used. When thallium iodide (TlI) is enclosed in addition to InI_3, an even higher lamp voltage can be obtained and the luminous efficiency can be increased

Table 1

lamp power (W)	Xe pressure (MPa)	enclosures as variable	lamp voltage(V) (lamp voltage per unit distance between electrodes (V/ cm))	the whole luminous flux(lm) (luminous efficiency (lm/W))	notes
35	0.7	InI_3 16mg/cc	73(173.8)	2100(60.0)	Embodiment 1
		InI_3 8mg/cc	50(119.0)	2500(71.4)	Embodiment 1
		InI 8mg/cc	45(107.1)	2600(74.3)	
		no InIx	27(64.3)	3000(85.7)	
	1.0	InI_3 4mg/cc	58(138.1)	3200(91.4)	Embodiment 2
	1.4	TlI 4mg/cc	70(166.7)	3250(92.9)	Embodiment 2
		InI_3 8mg/cc	70(166.7)	2800(80.0)	Embodiment 1
		InI 8mg/cc	-	-	
		no InIx	38(90.5)	3300(94.3)	
45	0.7	InI_3 8mg/cc	55(131.0)	3600(80.0)	Embodiment 1
		InI 8mg/cc	-	-	
		no InIx	27(64.3)	4200(93.3)	
	1.4	InI_3 8mg/cc	-	3800(84.4)	Embodiment 1
		InI 8mg/cc	-	-	
		no InIx	-	4500(100.0)	

[0066] As described above, when a mercury-free metal-halide lamp is constituted so as to comprise in its arc tube at least a trivalent of indium halide InX_3 (X:halogen), a rare gas and a thallium halide, it is possible to obtain a high lamp voltage corresponding to a metal halide lamp comprising mercury, and accordingly to provide a mercury-free metal-halide lamp having a very long life. Since InI_3 evaporates more easily than InI, a starting is facilitated. When xenon gas with an appropriate pressure below an upper limit of 2.5MPa is enclosed and a trivalent of indium halide (InX_3) and thallium halide with an appropriate amount below an upper limit of approximately 90.0 mg/cc per unit internal volume of the arc tube are enclosed, the light color of a mercury-free lamp in the present invention, in the case of operating at a lamp power of approximately 25 to 55W, is in a chromaticity range of the white light source specified in HID light sources for motor vehicle headlights (JEL 215) by the Japan Electrical Lamp Manufacturers Association. Then, more luminous flux occurs at less lamp power than a halogen lamp. This means that a mercury-free metal-halide lamp in the present invention can be substituted completely for a halogen lamp. Consequently, the mercury-free metal-halide lamp in the present invention contributes greatly to saving resources and energy, and can provide users with a great profit for economy and global environment.

[0067] An example of a mercury-free lamp wherein thallium iodide is enclosed is described in the above-mentioned Embodiment 2, and instead of the thallium iodide, thallium bromide (TiBr) may be enclosed or thallium chloride (TlCl) may be enclosed. Furthermore, metal of thallium and halogen may be enclosed separately.

[0068] An example of a mercury-free lamp wherein a trivalent of indium iodide (InI_3) is enclosed is described in each Embodiment, and instead of the bivalent of indium iodide (InI_3), a trivalent of indium bromide ($InBr_3$) may be enclosed, or a trivalent of indium iodide (InI_3) and a trivalent of indium bromide ($InBr_3$) may be enclosed.

[0069] A trivalent of indium iodide (InI_3) may be enclosed in the arc tube 1 by separating into a monovalent of indium iodide (InI) and iodine I_2. Similarly a trivalent of indium bromide ($InBr_3$) may be enclosed in the arc tube 1 by separating into a monovalent of indium bromide (InBr) and bromine Br_2. After enclosing a monovalent of indium iodide (InI) and bromine Br_2 in the arc tube 1, both trivalent of indium iodide (InI_3) and trivalent of indium bromide ($InBr_3$) may be

produced in the arc tube 1. In addition, such halides as InI (or InBr) and AgI (or AgBr), wherein halogen separates easily at a high temperature, may be enclosed. That is, it is preferred that the enclosures comprise InX_y (X: iodine or bromine, $y > 1$) substantially.

[0070] An example of a lamp comprising scandium iodide and sodium iodide besides xenon gas and a trivalent of indium iodide (InI_3) is described, and other halides of metal may be substituted for the scandium iodide and the sodium iodide.

[0071] For instance, scandium bromide may be substituted for the scandium iodide, and sodium bromide may be substituted for the sodium iodide. Furthermore, other metals such as thallium may be substituted for scandium and sodium. The enclosed amount of the halides of metal is not limited to the amount in the lamp of Embodiment 2.

[0072] In addition, the factors except a trivalent of indium halide and xenon gas, such as a distance between the electrodes, an internal volume of the arc tube 1, and the amount of scandium iodide and sodium iodide, are mere examples described in a mercury-free lamp in each of the Embodiments. For instance, a distance between the electrodes may be a value except 42 (mm), and an internal volume of the arc tube 1 is not limited to 0.025 (cc).

[0073] In the above-mentioned example, xenon gas with a pressure of approximately 0.7MPa or 1.4MPa at room temperature is enclosed in the arc tube 1 for the purpose of assisting the starting. Xenon gas is appropriate for rare gas in consideration of the utilization for motor vehicle headlights. In addition, rare gas except xenon gas such as argon gas may be used as the rare gas, and the enclosed pressure of rare gas is not limited to approximately 0.7MPa at room temperature.

[0074] Particularly preferable examples of the present invention are described in the above-mentioned Embodiments, and it goes without saying that such descriptions are not limited matters, but can have different variations. A mercury-free metal-halide lamp in Embodiments of the present invention is a mere example, and the limits of the present invention are determined by Claims.

Claims

1. A mercury-free metal halide lamp comprising at least a rare gas and a trivalent of indium halide in its arc tube.

2. A mercury-free metal-halide lamp according to Claim 1, wherein: said rare gas comprises at least Xe (xenon); and an enclosed pressure of said Xe is in a range of 0.1MPa to 2.5MPa at room temperature.

3. A mercury-free metal-halide lamp according to Claim 2, wherein: an enclosed pressure of said Xe is 0.7MPa or more at room temperature.

4. A mercury-free metal-halide lamp according to Claim 2 or 3 further comprising a thallium halide in its arc tube.

5. A mercury-free metal-halide lamp according to Claim 2, 3 or 4, wherein: an enclosed amount of said rare gas, an enclosed amount of said trivalent of indium halide and an operating power of said lamp are determined so that a lamp voltage per unit distance between electrodes is 100 V/cm or more and a luminous efficiency is 60 1 m/W.

6. A mercury-free metal-halide lamp according to any preceding Claim, further comprising at least one of a scandium halide and a sodium halide in its arc tube.

7. A mercury-free metal-halide lamp according to any preceding Claim, wherein:

8. A mercury-free metal-halide lamp according to any preceding Claim, wherein:
the operating power of said lamp is determined in a range of 25W to 55W.

9. A mercury-free metal halide lamp according to any preceding Claim wherein: said trivalent of indium halide is at least one of an iodide and a bromide.

Fig. 1

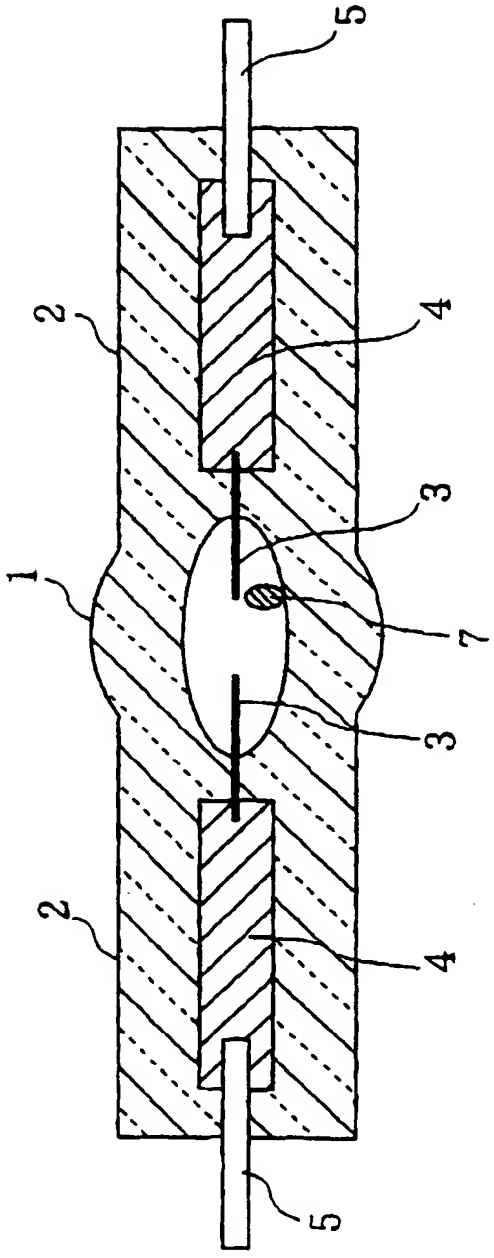


Fig. 2

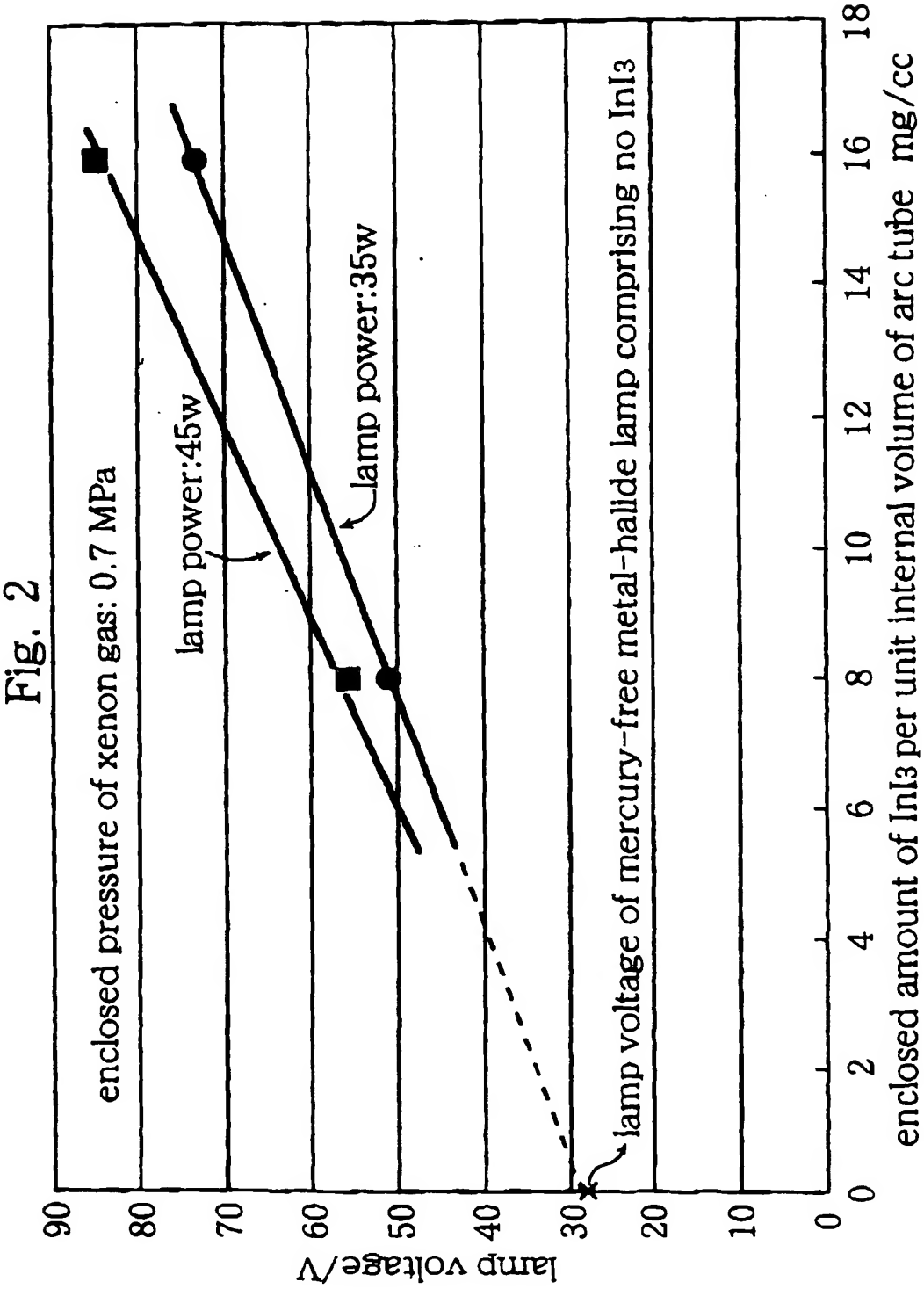


Fig. 3

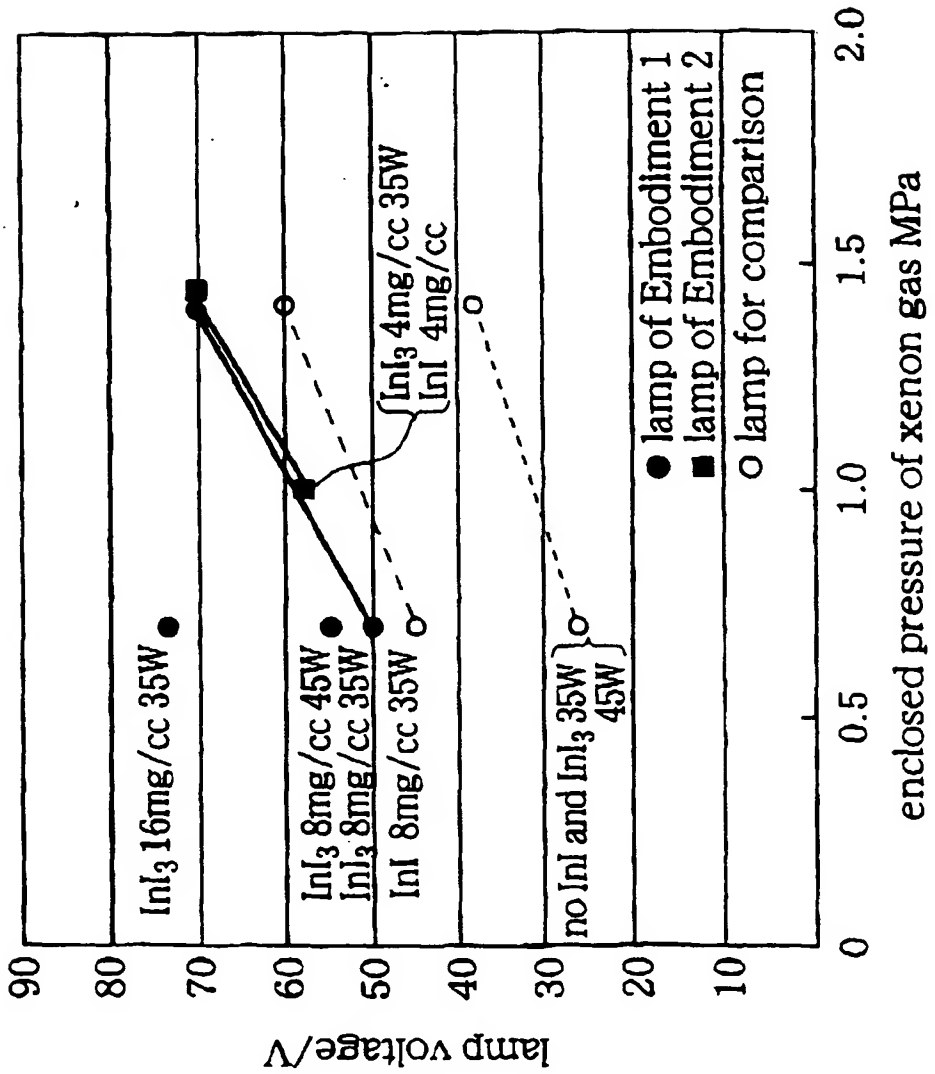


Fig. 4

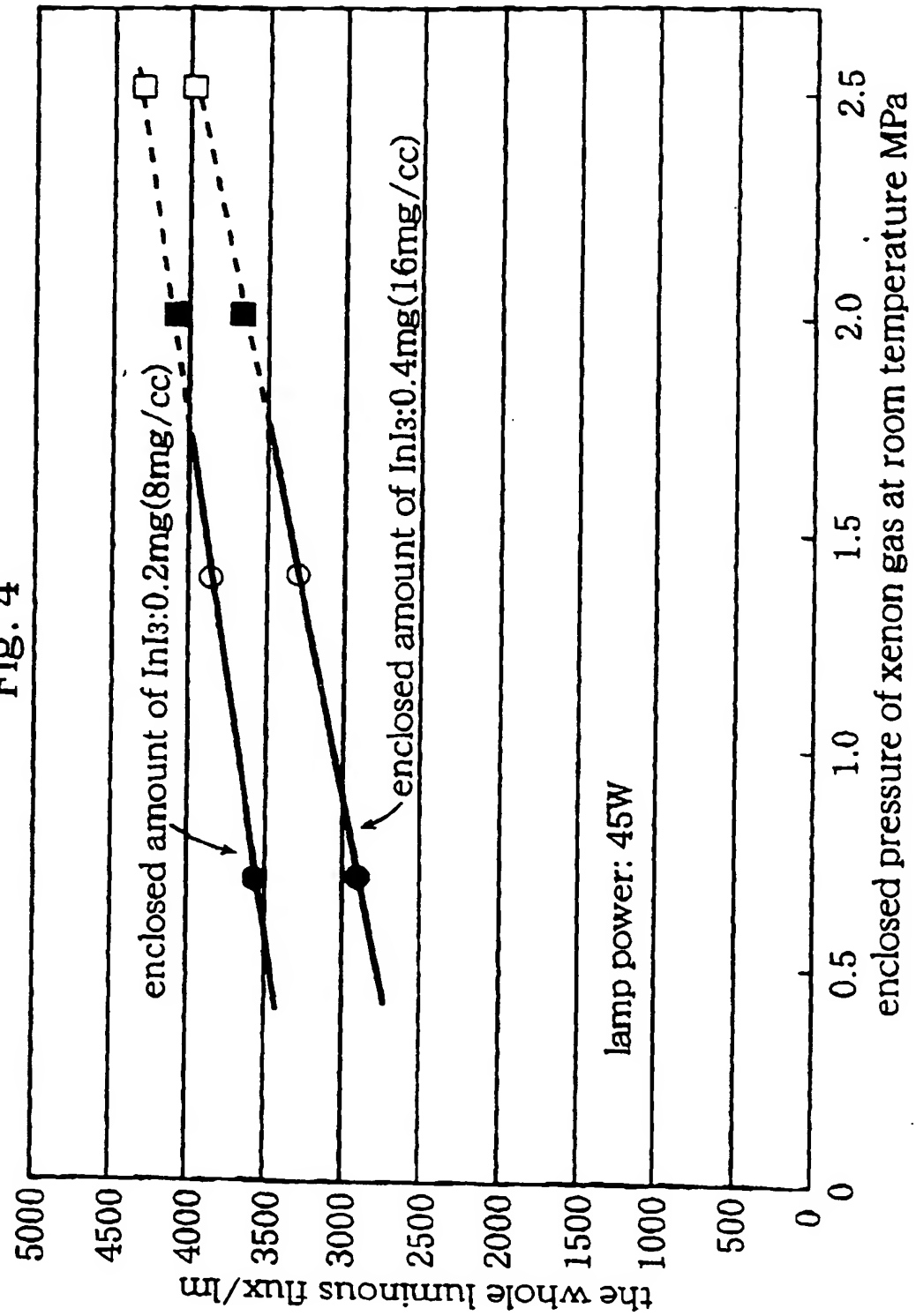
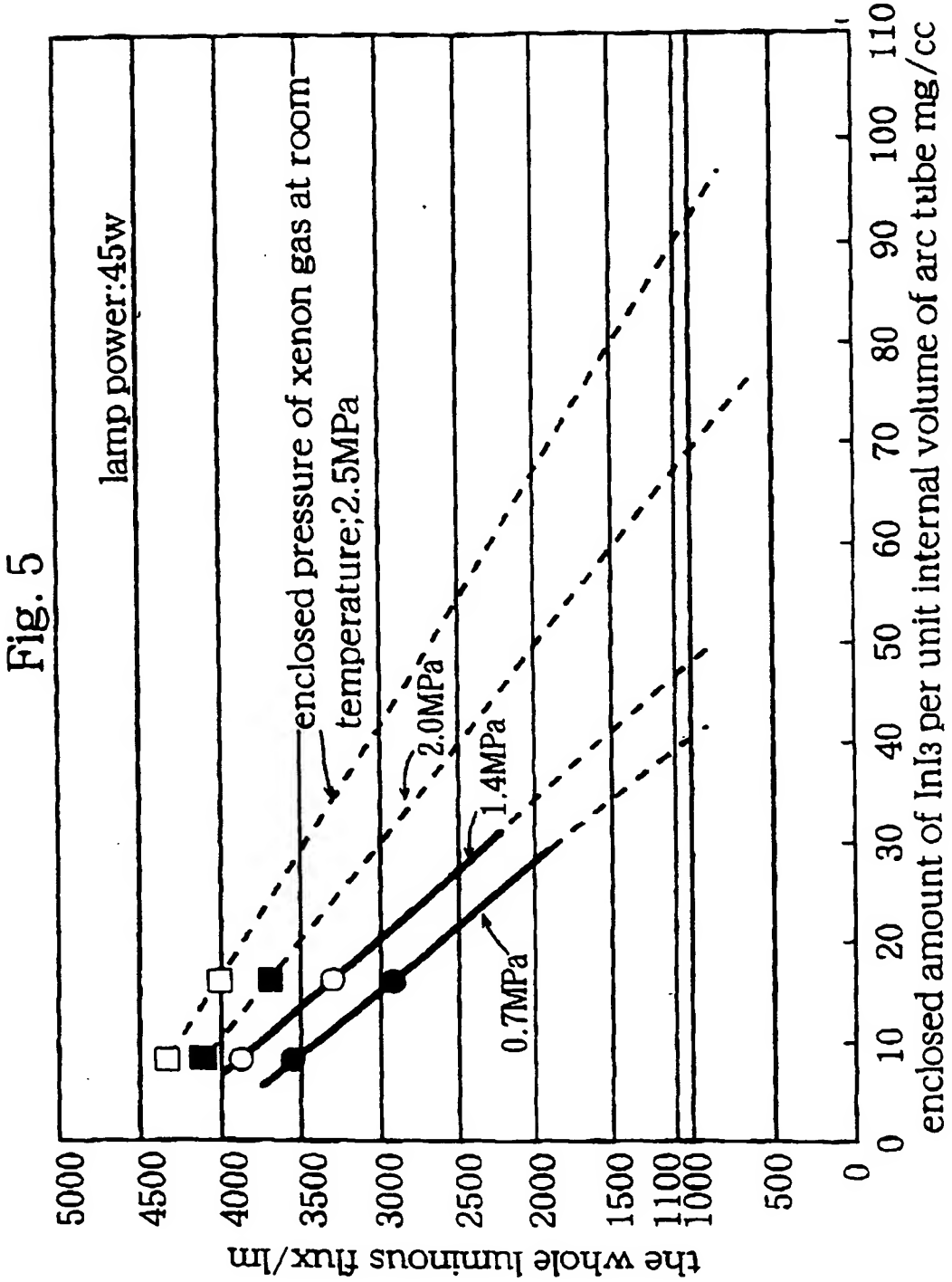


Fig. 5



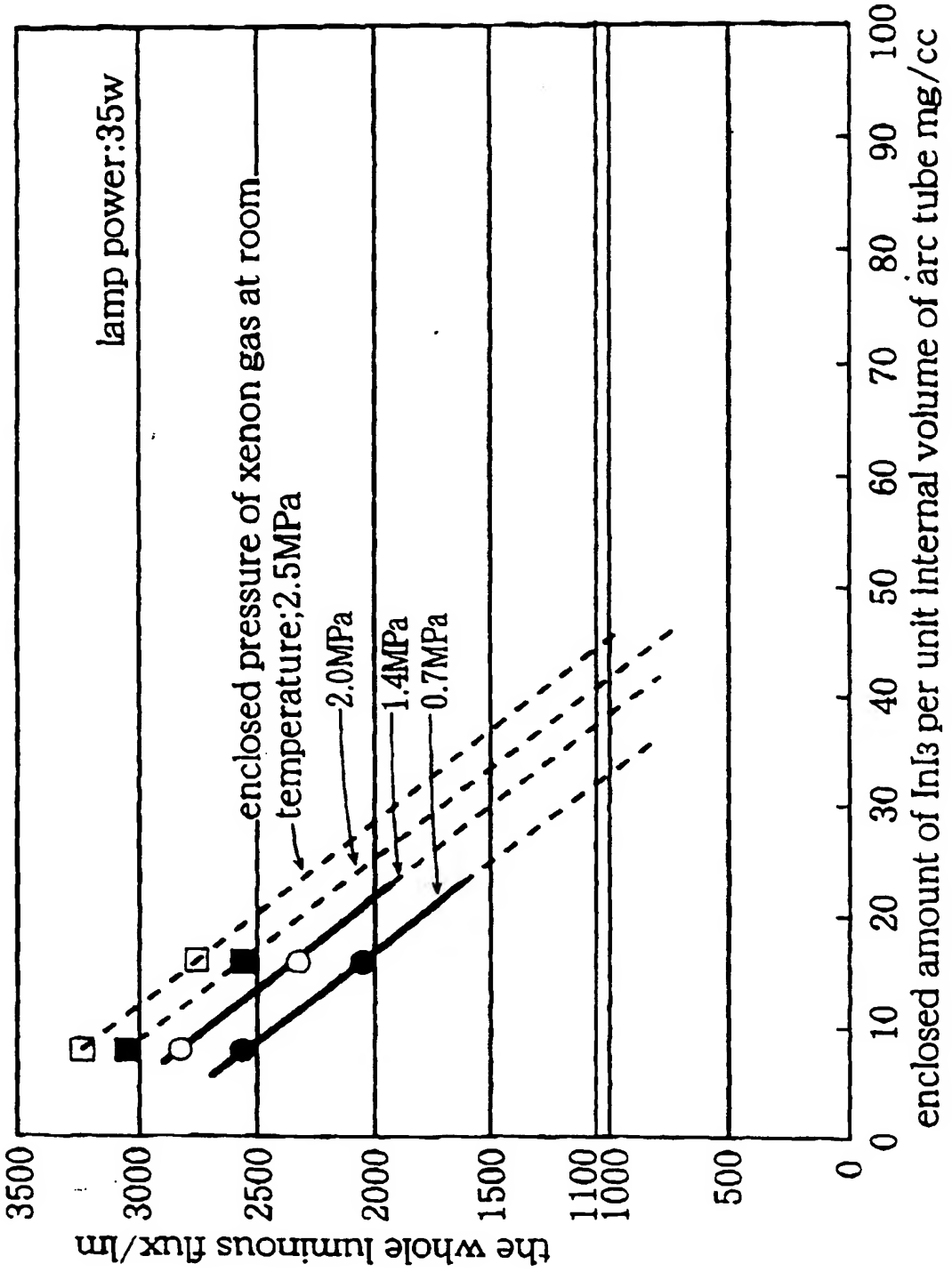


Fig. 6

Fig. 7

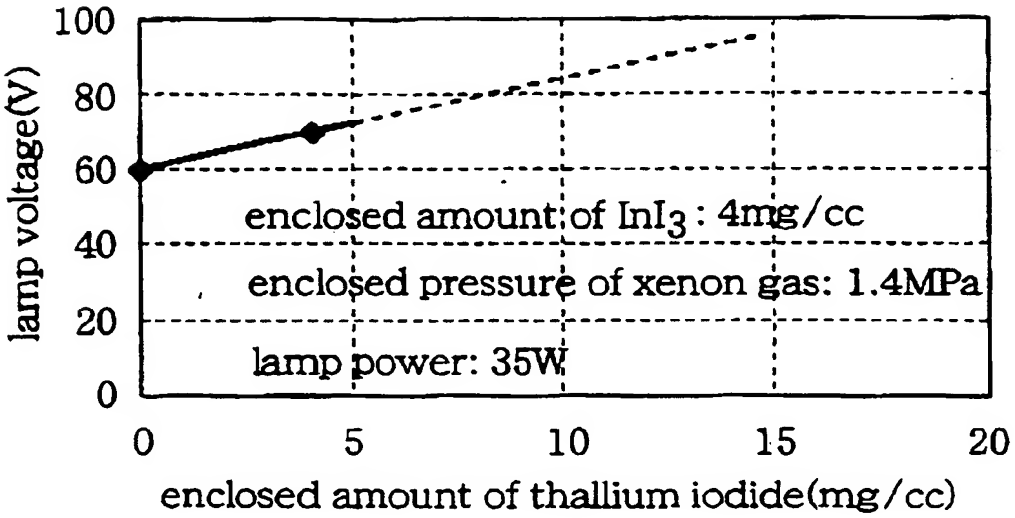


Fig. 8

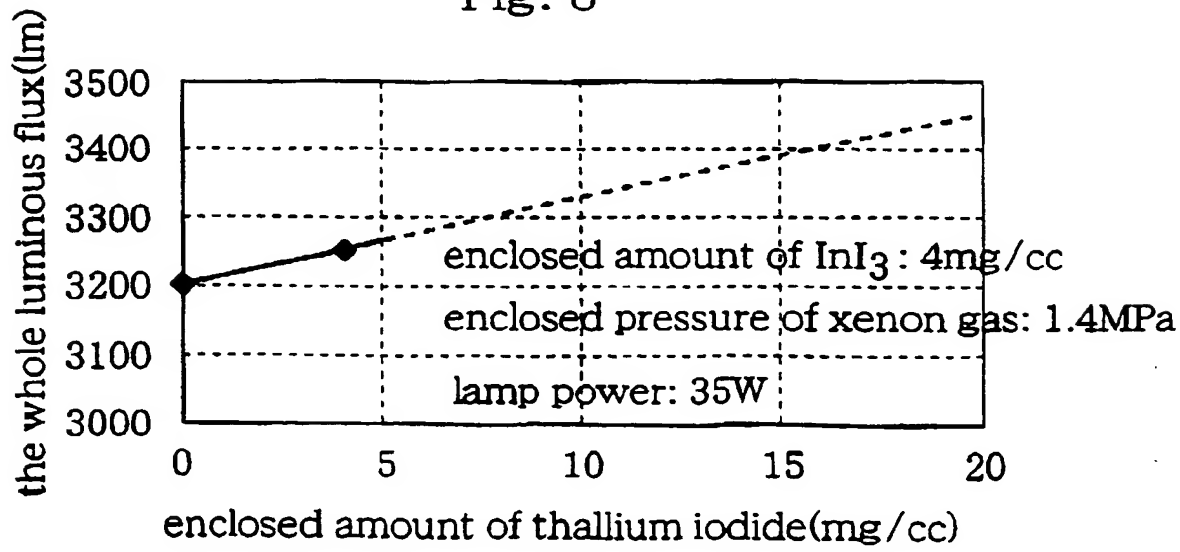


Fig. 9

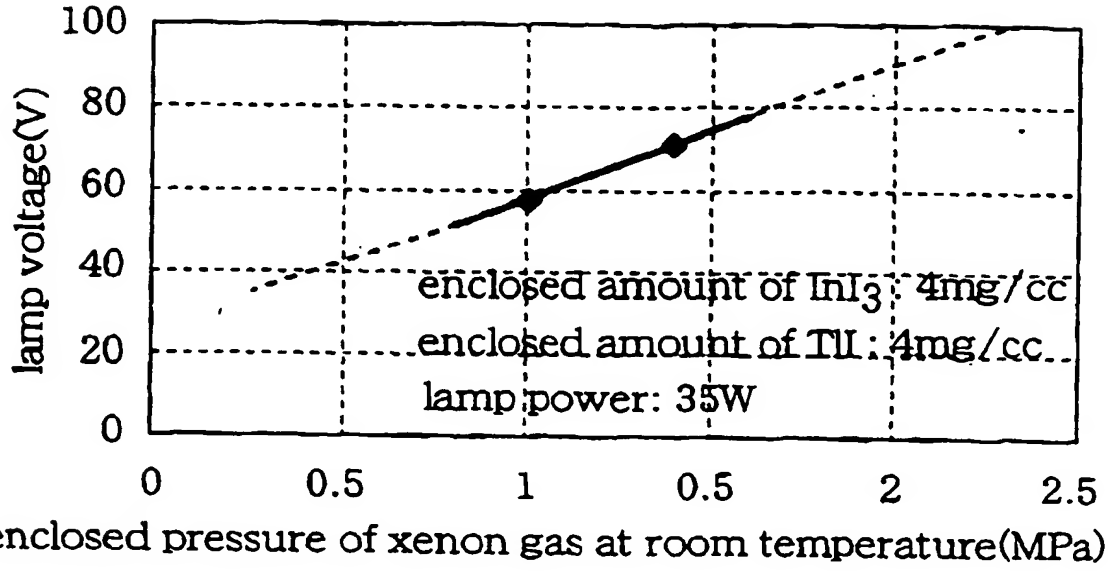


Fig. 10

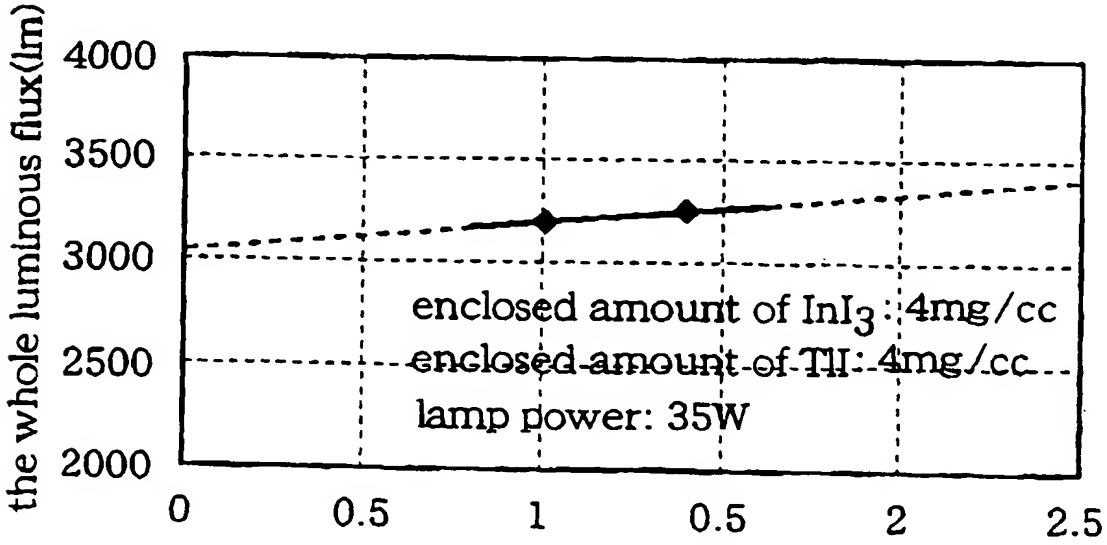


Fig. 11

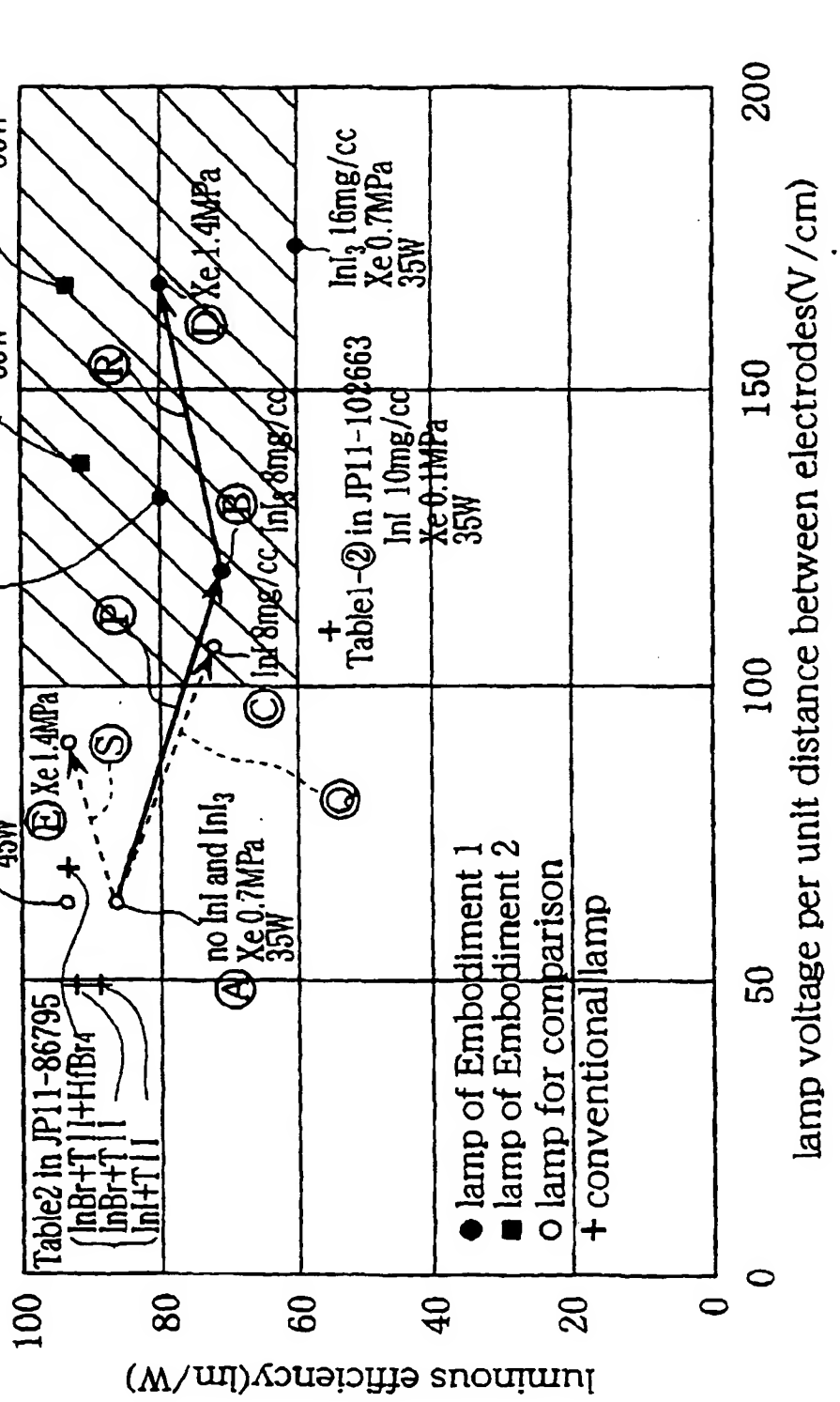
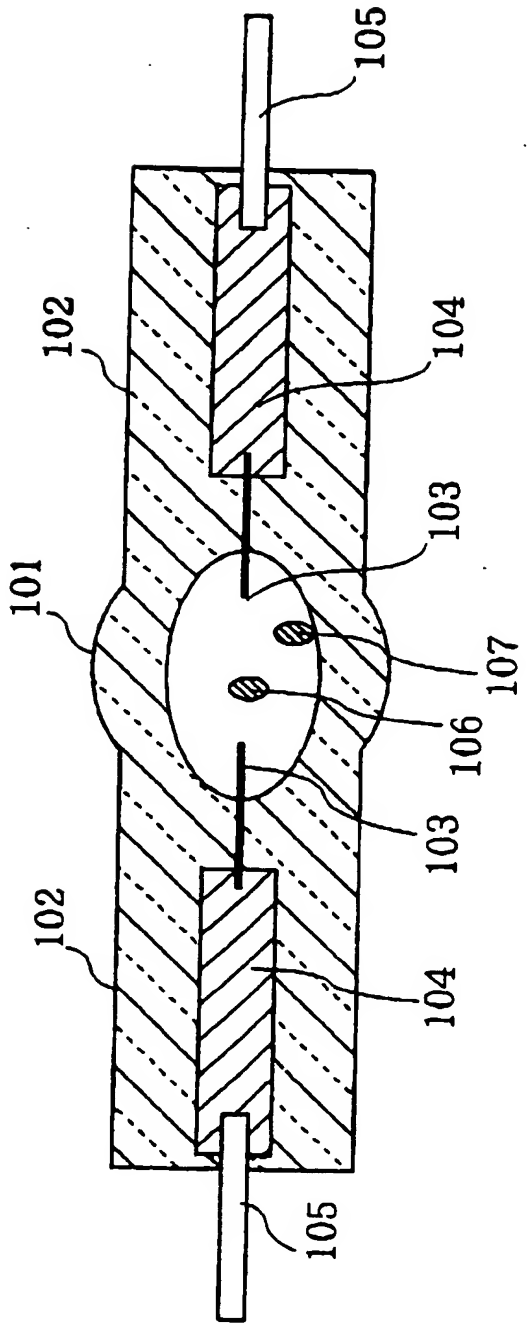


Fig. 12



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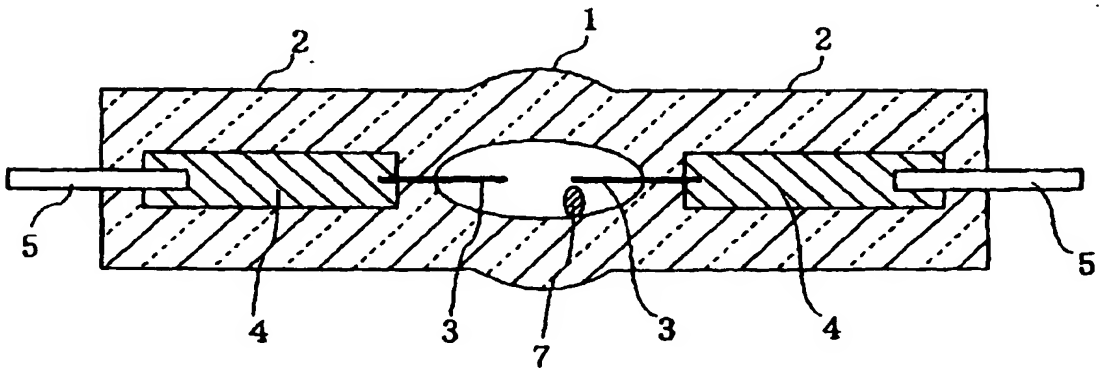
(54) Mercury-free metal halide-lamp

(57) A lamp voltage corresponding to a lamp comprising mercury is obtained by comprising at least a rare gas, a trivalent of indium halide and a thallium iodide in an arc tube 1, and thereby a long life can be accomplished. In addition, when an enclosed amount of the trivalent of indium halide is approximately 90.0mg/cc or less per unit internal volume of the arc tube and the rare gas is xenon gas with an enclosed pressure of 2.5MPa or less, the luminous flux and the light colour most appropriate for a light source for motor vehicle headlights are obtained. Furthermore, when the thallium iodide is enclosed, the lamp voltage can be made even higher and the luminous flux can be increased.

Fig. 1



EP 1 037 257 A3

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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 2009

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
E	EP 1 037 258 A (MATSUSHITA ELECTRIC IND CO LTD) 20 September 2000 (2000-09-20) * page 11, line 32 - line 50 *	1-4,6,8,9	H01J61/12 H01J61/82
E	EP 1 032 010 A (MATSUSHITA ELECTRIC IND CO LTD) 30 August 2000 (2000-08-30) * the whole document *	1-9	
E	EP 1 011 126 A (PATRA PATENT TREUHAND) 21 June 2000 (2000-06-21) * page 2, line 22 - line 24 * * page 4, line 31 - line 33 * * page 7, line 11 - line 13 * * table 1 *	1-4,6,9	
X	US 5 834 895 A (DOLAN JAMES T ET AL) 10 November 1998 (1998-11-10) * column 1, line 44 - line 46 * * column 4, line 22 - line 26 *	1,9	
X	US 3 259 777 A (FRIDRICH E.G.) 5 July 1966 (1966-07-05) * column 11, line 25 - line 27 *	1,9	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H01J
A	US 3 989 970 A (DOWNING ROBERT D) 2 November 1976 (1976-11-02) * column 1, line 8 - line 19 *	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	14 December 2000	Zuccatti, S

CATEGORY OF CITED DOCUMENTS

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The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-12-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1037258 A	20-09-2000	JP 2000090880 A	31-03-2000
		JP 11307048 A	05-11-1999
		CN 1256790 T	14-06-2000
		WO 9943020 A	26-08-1999
EP 1032010 A	30-08-2000	WO 0016360 A	23-03-2000
		EP 1037257 A	20-09-2000
EP 1011126 A	21-06-2000	DE 19857585 A	15-06-2000
		HU 9904194 A	28-06-2000
		JP 2000182564 A	30-06-2000
US 5834895 A	10-11-1998	US 5404076 A	04-04-1995
		US 5798611 A	25-08-1998
		US 5757130 A	26-05-1998
		US 5606220 A	25-02-1997
		US 5977724 A	02-11-1999
		US 5841242 A	24-11-1998
		US 6020676 A	01-02-2000
		US 6072268 A	06-06-2000
		US 5670842 A	23-09-1997
		US 5804922 A	08-09-1998
		US 5773918 A	30-06-1998
		US 5866980 A	02-02-1999
		US 5682080 A	28-10-1997
		US 5661365 A	26-08-1997
		US 5925981 A	20-07-1999
		WO 9321655 A	28-10-1993
		AT 151201 T	15-04-1997
		AU 662889 B	21-09-1995
		AU 8925191 A	26-05-1992
		BR 9107033 A	22-03-1994
		CA 2093921 A	26-04-1992
		DE 69125499 D	07-05-1997
		DE 69125499 T	17-07-1997
		DK 554350 T	22-09-1997
		EP 0554350 A	11-08-1993
		ES 2101759 T	16-07-1997
		GR 3023695 T	30-09-1997
		HU 214794 B	28-05-1998
		HU 65057 A	28-03-1994
		JP 10228886 A	25-08-1998
		JP 2931819 B	09-08-1999
		JP 6132018 A	13-05-1994
		KR 237859 B	15-01-2000
		RU 2130214 C	10-05-1999

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The members are as contained in the European Patent Office EDP file on
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14-12-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5834895 A		WO 9208240 A	14-05-1992
		US 5493184 A	20-02-1996
		AU 3977193 A	18-11-1993
		CA 2133344 A	28-10-1993
		EP 0636275 A	01-02-1995
		EP 1003204 A	24-05-2000
		HU 68508 A,B	28-06-1995
		JP 7509336 T	12-10-1995
		RU 2125322 C	20-01-1999
US 3259777 A	05-07-1966	NONE	
US 3989970 A	02-11-1976	US B534443 I	27-01-1976

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82